# *Solar Bulletin*

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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The Solar Bulletin of the AAVSO is a summary of each month's solar activity recorded by visual solar observers' counts of group and sunspots and the VLF radio recordings of SID Events in the ionosphere. Section 1 gives contributions by our members. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

## 1 Imaging the Sun

Figure 1 shows lots of structure in spot on the left. It had a flare earlier. iPhone 6 using Cortex camera application, TMB 175 and Herschel wedge. TMB 25 mm Zeiss eyepiece. Andrew Laszlo, September 6, 2017

Figure 1: Image of the large sunspot AR2673 September 2017.

A very large sunspot designated AR2763 produced 4 X class flares, one an X8.2 on September, 10 2017. This type activity was not expected as we move into solar minimum. Just goes to show how creative the sun can be.

# 2 Sudden Ionospheric Disturbance (SID) Report

Sudden ionospheric disturbances (SID) occur in Earth's atmosphere by solar flares, causing large increases in the ionization in the ionosphere over the daytime regions of the Earth.

## 2.1 SID Records

September 2017 (Figure 2) Rodney Howe captures the X8.2 flare recording data from NML (La Moure, ND at 25.2 kHz) at 1606 UT.

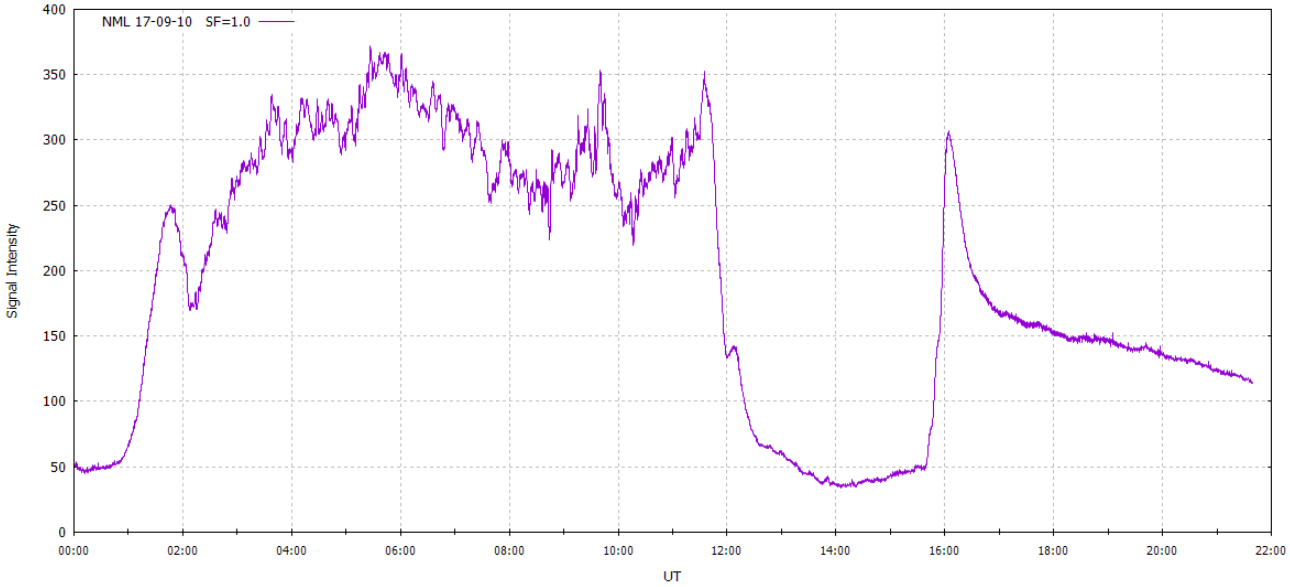


Figure 2: VLF recording of the largest X class flare in a decade on September 10, 2017

## 2.2 SID Observers

In September 2017 we have 14 AAVSO SID observers who submitted VLF data as listed in Table 1. Observers monitor from one to three stations to provide SID data.

Table 1: 201709 VLF Observers

| Observer | Code | Stations |
|---|---|---|
| A McWilliams | A94 | NML |
| J Wallace | A97 | NAA |
| L Loudet | A118 | DHO |
| J Godet | A119 | GBZ GQD ICV |
| B Terrill | A120 | NWC |
| F Adamson | A122 | NWC |
| S Oatney | A125 | NML |
| J Karlovsky | A131 | DHO NSY |
| R Green | A134 | NWC |
| S Aguirre | A138 | NPM |
| I Ryumshin | A142 | DHO GBZ |
| R Rogge | A143 | DHO GQD ICV |
| D Russel | A147 | NML |
| L Ferreira | A149 | NWC |

Figure 3 depicts the importance rating of the solar events. The durations in minutes are -1: LT 19, 1: 19-25, 1+: 26-32, 2: 33-45, 2+: 46-85, 3: 86-125, and 3+: GT 125.

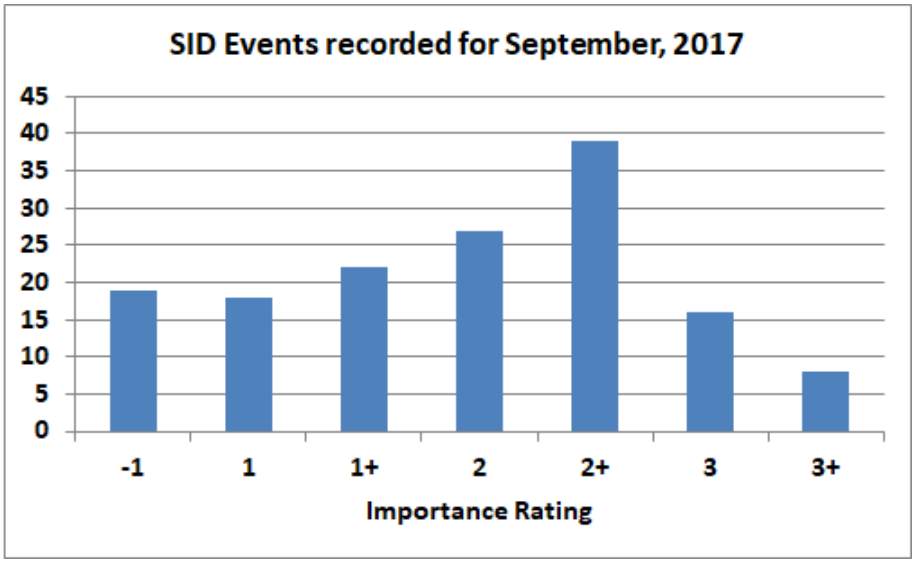


Figure 3: Solar Events Y-axis, Importance Rating X-axis.

### 2.3 Solar Flare Summary from GOES-15 Data

In September 2017, there were 149 solar flares measured by GOES-15 (see Figure 4). Four X class, 24 M class, 67 C class, and 54 B class flares. A little less flaring this month compared to last, but still with 8 days of no reports from the GOES satellite.

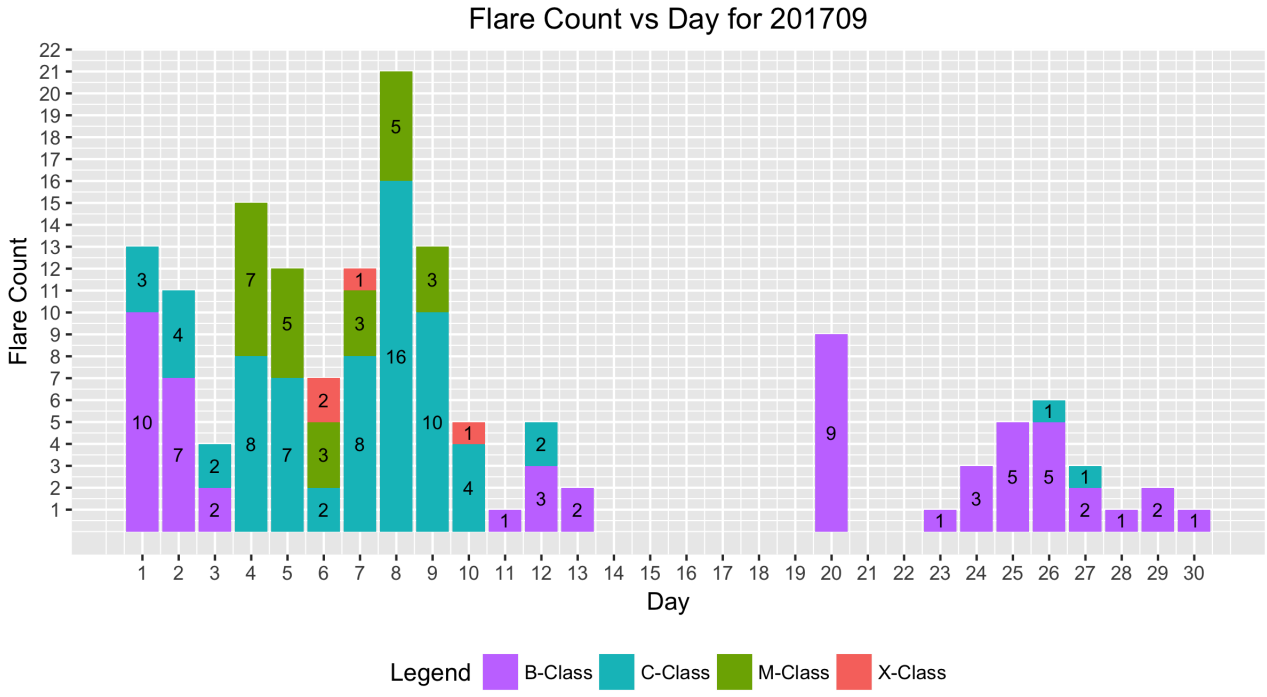


Figure 4: GOES - 15 XRA flares

## 3 Relative Sunspot Numbers (Ra)

Reporting monthly sunspot numbers consists of submitting an individual observer's daily counts for a specific month to the AAVSO Solar Section. These data are maintained in a SQL database. The monthly data then are extracted for analysis. This section is the portion of the analysis concerned with both the raw and daily average counts for a particular month. Scrubbing and filtering the data assure error-free data are used to determine the monthly sunspot numbers.

### 3.1 Raw Sunspot Counts

The raw daily sunspot counts consist of submitted counts from all observers who provided data in September 2017. These counts are reported by the day of the month, and are either from data not scrubbed or corrected data.

The reported raw daily average counts have been checked for errors and inconsistencies, and no known errors are present. All observers whose submissions qualify through this month's scrubbing process are represented in Figure 6.

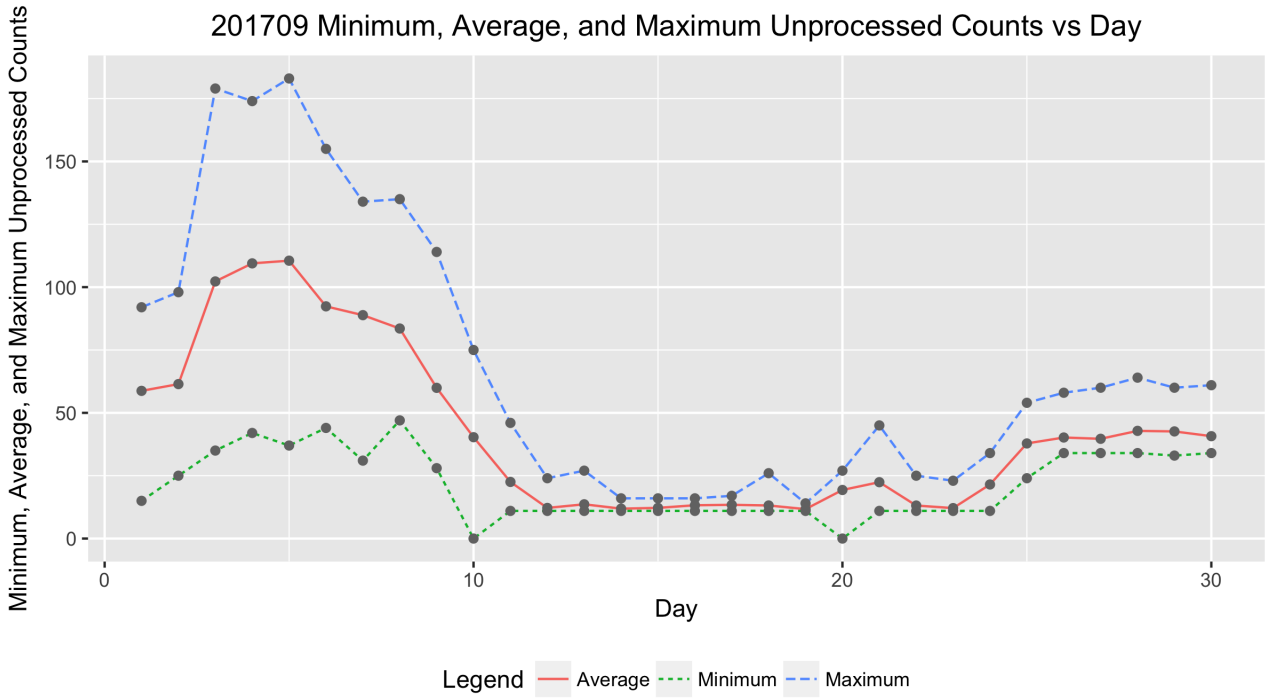


Figure 5: Raw average, minimum and maximum counts by day of the month by observer.

### 3.2 American Relative Sunspot Numbers

The relative sunspot numbers, $R_a$ contain the sunspot numbers after the submitted data are scrubbed and modeled by Shapley's method with $k$-factors http://iopscience.iop.org/article/10.1086/126109/pdf. The Shapley method is a statistical model that agglomerates variation due to random effects such as observer and fixed effects such as seeing condition. See Table 2.

Table 2: 201709 American Relative Sunspot Numbers (Ra)

| Day | NumObs | Raw | Ra |
|---|---|---|---|
| 1 | 39 | 61 | 48 |
| 2 | 39 | 65 | 50 |
| 3 | 41 | 105 | 85 |
| 4 | 37 | 118 | 92 |
| 5 | 36 | 113 | 88 |
| 6 | 39 | 94 | 80 |
| 7 | 36 | 95 | 81 |
| 8 | 35 | 86 | 67 |
| 9 | 41 | 59 | 49 |
| 10 | 38 | 40 | 31 |
| 11 | 36 | 21 | 16 |
| 12 | 33 | 13 | 11 |
| 13 | 40 | 13 | 10 |
| 14 | 37 | 12 | 10 |
| 15 | 40 | 13 | 11 |

Continued

Table 2: 201709 American Relative Sunspot Numbers (Ra)

| Day | NumObs | Raw | Ra |
|---|---|---|---|
| 16 | 37 | 14 | 11 |
| 17 | 38 | 14 | 11 |
| 18 | 38 | 13 | 11 |
| 19 | 40 | 12 | 9 |
| 20 | 37 | 21 | 17 |
| 21 | 40 | 22 | 19 |
| 22 | 37 | 13 | 11 |
| 23 | 35 | 12 | 10 |
| 24 | 41 | 22 | 17 |
| 25 | 36 | 37 | 31 |
| 26 | 36 | 40 | 31 |
| 27 | 34 | 39 | 30 |
| 28 | 30 | 43 | 34 |
| 29 | 31 | 43 | 33 |
| 30 | 29 | 40 | 34 |
| Averges | 36.9 | 43.1 | 34.6 |

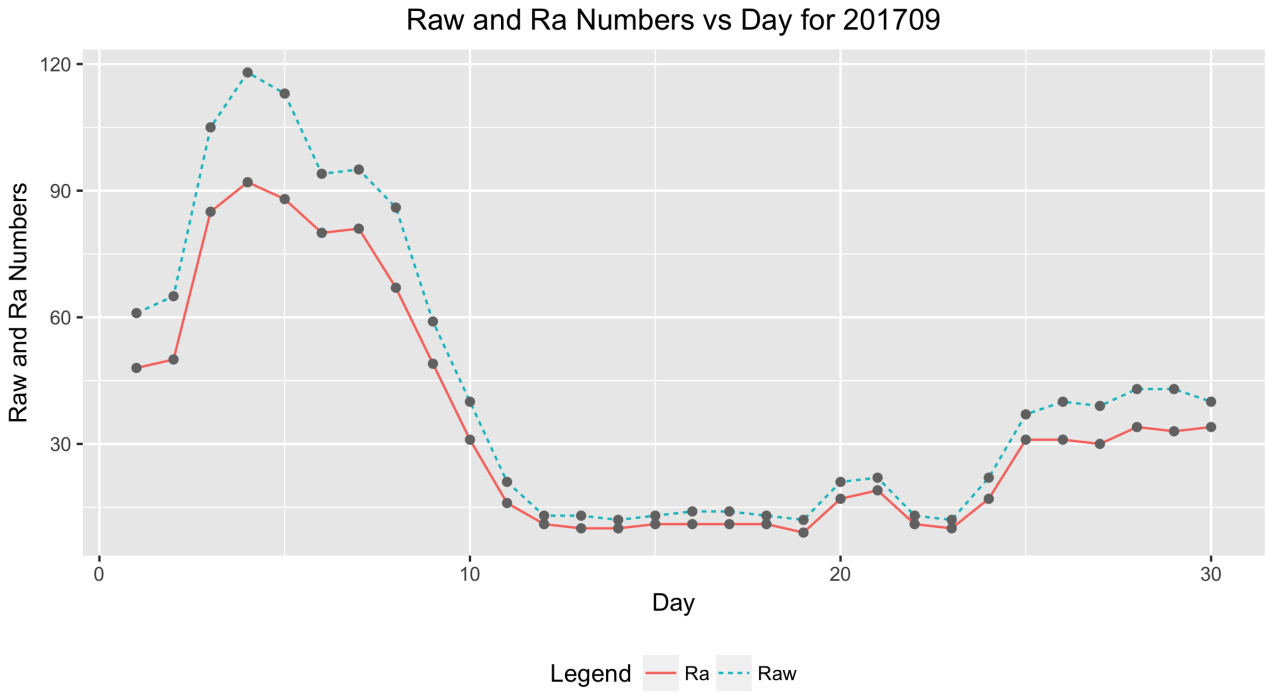


Figure 6: Raw Wolf and Ra numbers by day of the month by observer.

### 3.3 Sunspot Observers

Table 3 lists the observer code (obs), the number of observations submitted for September 2017, and the observer's name. The final rows of the table give the total number of observers who submitted sunspot counts and the total number of observations submitted. The total number of observers is 64 and the total number of observations is 1106.

Table 3: 201709 Number of observations by observer

| Obs | NumObs | Name |
|---|---|---|
| AAP | 4 | A. Patrick Abbott |
| AAX | 13 | Alexandre Amorim |
| AJV | 27 | J. Alonso |
| ARAG | 30 | Gema Araujo |
| ASA | 18 | Salvador Aguirre |
| BARH | 6 | Howard Barnes |
| BERJ | 24 | Jose Alberto Berdejo |
| BMF | 21 | Michael Boschat |
| BRAB | 25 | Brenda Branchett |
| BRAF | 20 | Raffaello Braga |
| BROB | 30 | Robert Brown |
| BSAB | 15 | Santanu Basu |
| CHAG | 28 | German Morales Chavez |
| CIOA | 11 | Ioannis Chouinavas |
| CKB | 29 | Brian Cudnik |
| CNT | 8 | Dean Chantiles |
| CVJ | 23 | Jose Carvajal |
| DEMF | 8 | Frank Dempsey |
| DJOB | 21 | Jorge del Rosario |
| DUBF | 27 | Franky Dubois |
| FERJ | 26 | Javier Ruiz Fernandez |
| FLET | 25 | Tom Fleming |
| FLF | 25 | Fredirico Luiz Funari |
| FUJK | 21 | K. Fujimori |
| HAYK | 21 | Kim Hay |
| HIVB | 1 | Ivan Hajdinjak |
| HOWR | 25 | Rodney Howe |
| JDAC | 19 | David Jackson |
| JENS | 4 | Simon Jenner |
| JGE | 9 | Gerardo Jimenez Lopez |
| JPG | 19 | Penko Jordanov |
| KAND | 19 | Kandilli Observatory |
| KAPJ | 16 | John Kaplan |
| KNJS | 30 | James & Shirley Knight |
| LEVM | 24 | Monty Leventhal |
| LKR | 9 | Kristine Larsen |
| LRRA | 24 | Robert Little |
| MARE | 8 | Enrico Mariani |

Continued on next page

Table 3: 201709 Number of observations by observer

| Obs | NumObs | Name |
|---|---|---|
| MCE | 22 | Etsuiku Mochizuki |
| MILJ | 13 | Jay Miller |
| MJAF | 30 | Juan Antonio Moreno Quesada |
| MJHA | 27 | John McCammon |
| MMAE | 3 | Aaron McNeely |
| MUDG | 15 | George Mudry |
| MWU | 18 | Walter Maluf |
| OATS | 6 | Susan Oatney |
| ONJ | 6 | John O'Neill |
| PMAJ | 1 | Mantheos Papapoulias |
| SDOH | 30 | Solar Dynamics Obs - HMI |
| SIMC | 2 | Clyde Simpson |
| SMNA | 5 | Michael Stephanou |
| SNE | 10 | Neil Simmons |
| SONA | 6 | Andries Son |
| STAB | 30 | Brian Gordon-States |
| SUZM | 22 | Miyoshi Suzuki |
| TESD | 26 | David Teske |
| TPJB | 3 | Patrick Thibault |
| URBP | 18 | Piotr Urbanski |
| VARG | 25 | A. Gonzalo Vargas |
| VIDD | 14 | Dan Vidican |
| WGI | 1 | Guido Wollenhaupt |
| WILW | 27 | William M. Wilson |
| WRP | 4 | Russell Wheeler |
| Totals | 1106 | 64 |

### 3.4 Generalized Linear Model of Sunspot Numbers

Dr. Jamie Riggs, Solar System Science Section Head, International Astrostatistics Association, maintains a relative sunspot number ($R_a$) model containing the sunspot numbers after the submitted data are scrubbed and modeled by a Generalized Linear Mixed Model (GLMM), which is a different model method from the Shapley method of calculating $R_a$ in Section 3 above. The GLMM is a statistical model that accounts for variation due to random effects and fixed effects. For the GLMM $R_a$ model random effects include the AAVSO observer as these observers are a selection from all possible observers, and the fixed effects include seeing conditions at one of four possible levels. More details on GLMM are available in a paper (GLMM05) on the sunspot counts research page. The paper title is *A Generalized Linear Mixed Model for Enumerated Sunspots.*

Figure 7 shows the monthly GLMM $R_a$ numbers. The solid cyan curve that connects the red X's is the GLMM model $R_a$ estimates of excellent seeing conditions, which in part explains why these $R_a$ estimates often are higher than the Shapley $R_a$ values. The dotted black curves on either side of the cyan curve depict a 99% confidence band about the GLMM estimates. The confidence band uses the large sample approximation based on the Gaussian distribution. The green dotted curve connecting the green triangles is the Shapley method $R_a$ numbers. The dashed blue curve

connecting the blue O's is the SILSO values for the monthly sunspot numbers.

The tan box plots for each month are the actual observations submitted by the AAVSO observers. The heavy solid lines approximately midway in the boxes represent the count medians. The box plot represents the InterQuartile Range (IQR), which depicts from the $25^{th}$ through the $75^{th}$ quartiles. The lower and upper whiskers extend 1.5 times the IQR below the $25^{th}$ quartile, and 1.5 times the IQR above the $75^{th}$ quartile. The black dots below and above the whiskers traditionally are considered outliers, but with GLMM modeling, they are observations that are accounted for by the GLMM model.

# 4 Endnotes

Reporting Addresses

- Sunspot Reports: Kim Hay solar@aavso.org
- SID Solar Flare Reports: Rodney Howe ahowe@frii.com

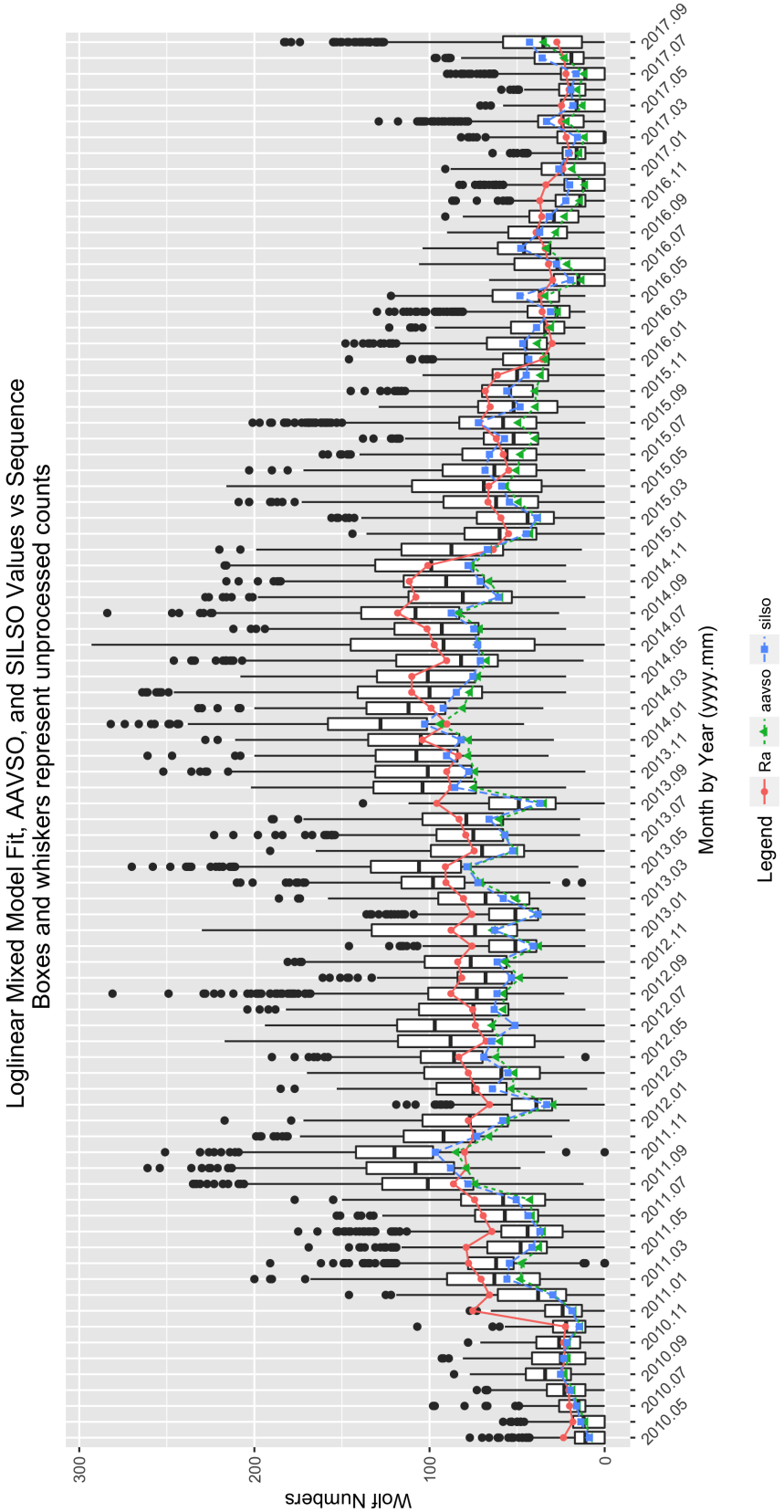


Figure 7: GLMM fitted data for $R_a$. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels